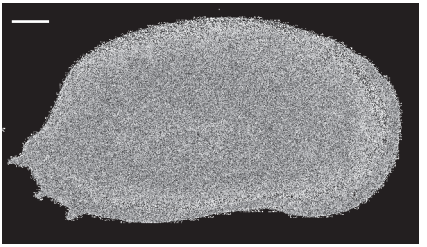
Tóth Emőke

Palaeoenvironmental reconstruction of the Sarmatian Central Paratethys based on micropalaeontological and geochemical analyses

THESES OF DISSERTATION



Eötvös Loránd University, Faculty of Sciences
Ph.D. school of Geosciences
Geology-Geophysics Ph.D. Program
Head of Ph.D. school: Prof. Miklós Monostori D.Sc.

Université Claude Bernard Lyon 1
École Doctorale: Évolution Écosystèmes Microbiologie Modélisation
Head of Ph.D. school:Jean-Pierre Flandrois

Supervisors:

ÁGNES GÖRÖG, Ph.D. assistant professor
Professor MIKLÓS MONOSTORI,
ELTE Department of Palaeontology

PIERRE MOISSETTE, MC (HDR)
CHRISTOPHE LÉCUYER, PR (HDR)
UMR 5125 (PEPS)

ELTE Őslénytani Tanszék/Université Claude Bernard Lyon 1
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Introduction

The Paratethys was an epicontinental sea that developed as a relict of the ancient Tethys Ocean. It existed between the Early Oligocene and the late Middle Miocene. The uplift of the Dinarids during the Middle Miocene caused a distinct change in the oceanographic and biotic evolution of the Paratethys. This geodynamic process interrupted or limited the connections between the Paratethys and the Mediterranean and was the main cause of distinct palaeobiological developments in these bioprovinces. In the Pannonian Basin of the Central Paratethys, the changes in palaeoenvironmental conditions caused by the above-mentioned tectonic instability resulted in a characteristic evolution of the flora and fauna at the beginning of the Sarmatian. At the Badenian/Sarmatian boundary, several marine stenohaline groups of organisms disappeared (i.e. radiolarians, corals, scaphopods, cephalopods, polyplacophorans, brachiopods, and echinoids) and among other groups it was mostly the euryhaline forms that persisted into the Sarmatian Central Paratethys. Currently there is still discussion focused on the environmental factors that changed in the Sarmatian sea causing the biotic modifications. The Sarmatian fauna was classically regarded as a brackish-water community (e. g. BODA, 1959) within gradually decreasing salinity. However, several authors have suggested recently that the Sarmatian sea was in fact more or less marine, even with hypersaline episodes, and explained the diversity fall by significant changes in water chemistry, especially high alkalinity (e. g. PILLER & HARZHAUSER, 2005).

Aims

The main aim of the present work is to identify the major palaeoenvironmental changes that occurred during the Sarmatian, with the help of palaeontological (ostracods and foraminifera) and geochemical methods. Similar detailed and integrated studies from a complete Sarmatian section have not yet been made from the region of the Paratethys. For the palaeoecological interpretations it is essential to give a detailed systematical description of the ostracods. Detailed taxonomic work on the Hungarian Sarmatian ostracods has not been published since the first descriptions accomplished by ZALÁNYI in 1913. Further goal of this work is the taxonomical description of the foraminifera fauna of Budapest because detailed analyses of Sarmatian foraminifers from this region has not been published yet. Moreover the stratigraphical interpretation of the ostracod fauna was also very important because the Sarmatian palaeoenvironmental changes correspond essentially to the boundaries of the

foraminiferal zones. For the identification of the microfaunal differences in the different parts of the central basin of the Central Paratethys I have attempted to investigate the microfaunas of numerous Sarmatian successions from Hungary. The most complete analyses was made from the Zsámbék Basin. Thus further aim of this work was to study how the Sarmatian successions of the Zsámbék Basin represent the main palaoenvironmental changes in the entire Central Paratethys.

Methods

Among the fourty-three studied Sarmatian successions from Hungary, the most detailed analyses were made from two boreholes in the Zsámbék Basin that penetrated almost complete Sarmatian successions. Ninety-eight samples from two boreholes were studied for their faunal content and fifty-two samples analysed for their trace element (Mg/Ca, Sr/Ca and Ba/Ca) and stable isotope compositions. Detailed taxonomic description, stratigraphical and palaeoecological interpretation were used for the palaeoenvironmental reconstruction. These results are complemented with the palaeoecological interpretation of the foraminifera fauna. The palaeoecological interpretation of the microfauna was made based on qualitative (taxonomic composition of the fauna) and quantitative analyses (total diversity and Jaccard's Coefficient of Community). The palaeontological investigations were complemented with the studies of Sarmatian successions from other boreholes (n=50) and outcrops (n=7) from the Zsámbék and Mány Basin, from the boreholes and outcrops from the other parts of the Central Paratethys (Budajenő (n=10), Csákvár (n=71), Polgárdi (n=32), Budapest (n=129), Tokaj Mountains (n=20), Duna-Tisza Interfluve (n=22 minta), Mecsek Mountains (n=7) and Slovenia (n=15). The palaeoecological interpretation of the studied microfauna was made based mainly on recent analogies. The systematic description, the stratigraphical and palaeoecological interpretation of the foraminifera fauna were made only from Budapest because the foraminifera faunas from other parts of the studied successions already have been published. For the geochemical investigations first I checked by X-ray diffraction technique wether the aragonitic shells of gastropods preserved their original crystal structure. Therefore the trace elemental and stable isotope values derived from gastropod shells are useful for palaeoenvironmental interpretations. Trace element analyses have been performed on twenty-seven samples of foraminifers (*Elphidium* spp.) and gastropods (*Mohrensternia inflata, Granulolabium bicinctum, Potamides disjunctus, Hydrobia hoernesi, Cerithium rubiginosum*). One hundred seven carbon and oxygen isotope compositions were determined

for four species of foraminers (*Elphidium aculeatum, E. hauerinum, E. macellum*, and *Ammonia beccarii*), two ostracod species (*Aurila mehesi* and *A. notata*), and five gastropod species (*Mohrensternia inflata, Granulolabium bicinctum, Potamides disjunctus, Hydrobia hoernesi*, and *Cerithium rubiginosum*). Oxygen isotope compositions of phosphate rodent teeth extracted from the Sarmatian non-marine series of Felsőtárkány and Tăşad were used to estimate the $\delta^{18}O$ value of local freshwater, itself a proxy of mean air temperatures (Von Grafenstein et al., 1996).

New scientific results

1. *Taxonomic results*

1.1. From the fourty-three studied Sarmatian successions from Hungary detailed systematic descriptions and illustrations of 36 ostracod taxa are provided.

1.2. I gave the main characteristics of the ostracod fauna in comparison with the faunas from other subbasins of the Central Paratethys and with the assemblages of the Mediterranean and the Eastern Paratethys. I recognized that the studied ostracod fauna from Hungary was very uniform in the central subbasin of the Central Paratethys. I showed that this fauna was most similar to that of the Vienna Basin among the peripherical subbasins. The comparison with the faunas of Mediterranean and the Eastern Paratethys argues in favour of a very limited connection between the Paratethys and the Mediterranean at the Badenian/Sarmatian boundary but the seaway between the Central Paratethys and Eastern Paratethys existed until the end of the Sarmatian.

1.3. Twenty-eight foraminifera taxa could be determined from the studied Sarmatian successions of Budapest. I made the modern taxonomic descriptions of these taxa. I recognized that the studied assemblage shows the highest similarity to the foraminifera fauna of the Zsámbék Basin. It can be explained with the short geographical distance. Inside the Paratethys the studied fauna is mostly resembled to the assemblages of the Eastern Paratethys.

2. *Stratigraphical results*

2.1. I studied how the ostracod biozones introduced by JIŘIČEK (1983) and ZELENKA (1990) can be adopted to the studied Sarmatian successions of Hungary and how the Sarmatian series correlate with each other based on the studied ostracod fauna. The Sarmatian deposits could be divided into two zones based on the ostracod assemblags (*Cytheridea hungarica* - *Aurila mehesi* and *Aurila notata* Zones) and the uppermost Sarmatian beds could be ranged into a subzone (*Hemicytheria hungarica*-*Leptocythere cejcensis* Subzone).

2.2. Based on the studies of boreholes from the Zsámbék Basin I showed that the boundary of the *Cytheridea hungarica* - *Aurila mehesi* and the *Aurila notata* Zones well coincides with the boundary of the *Elphidium reginum*/*Elphidium hauerinum* foraminifera Zones and of the substages based on mollusc faunas.

2.3. On the basis of the comparison of the ostracod zones with other biozones I recognized that the Sarmatian *s. str*. could be distinguished surely two biozones, but the Upper Sarmatian beds could only be divided ecostratigraphically.

2.4. Based on the stratigraphical interpretation of the foraminifera from Budapest I pointed out that the studied successions can be ranged into the *Elphidium reginum* Zone (Early Sarmatian) and that the *Anomalinoides dividens* Zone is missing from the studied sections as well as from other Hungarian localities.

3. *Palaeoecological results*

3.1. I gave the palaeoecological interpretation of the ostracod fauna in the studied successions from Hungary. This was complemented by the interpretation of the foraminifera fauna partly from by own studies partly from the literature. I based the ecological characterization of the taxa mainly on recent analogies.

3.1.1. I made a palaeoecological interpretation of the ostracod fauna from the Zsámbék Basin. The palaeoecological study of the foraminifera is mainly

adapted from GÖRÖG (1992). These results are complemented with and compared to the interpretation of the ostracod fauna. I identified the changes of water depth, water temperature, salinity and oxygen content for the Sarmatian in this subbasin of the Central Paratethys based on the study of the microfaunal composition.

3.1.2. I interpreted palaeoecologically the foraminfera and ostracod fauna from Budapest. I recognized that the general composition of the studied microfauna (foraminifers, ostracods) suggests the dominance of an epiphytic benthic community during the Early Sarmatian (*Elphidium reginum* Zone) in this region of the Central Paratethys. Moreover I showed that the composition of the microfauna was influenced by the type of the phytal substrates, the nutrients, the water depth, the oxygen content and the salinity.

3.1.3. On the basis of the palaeoecological interpretation of the ostracod fauna from the Tokaj Mountains, Duna-Tisza Interfluve and Mecsek Mountains and on the comparison with the faunas from the Zsámbék Basin and Budapest I showed that the different parts of the central subbasin of the Central Paratethys were characterized by similar brackish conditions during the Early Sarmatian except the subbasin of Budajenő. This fact is confirmed by the uniform compositions of the microfaunas from the different Sarmatian successions of Hungary.

3.2. I completed and specified the palaeoecological interpretation of the microfauna from the Zsámbék Basin with stable isotope and trace element analyses.

3.2.1. I showed changes in the bottom water temperature in this subbasin of the Central Paratethys during the Sarmatian on the basis of the Mg/Ca profile of the gastropod shells.

3.2.2. I demonstrated the salinity changes during the Sarmatian in this region based on the $\delta^{18}O$ and $\delta^{13}C$ profiles of the foraminifera and ostracod shells.

3.2.3. I showed changes in the dissolved inorganic carbon content of the seawater based on the $\delta^{13}C$ compositions of the foraminifera and ostracod shells.

3.2.4. I reconstructed the variations of the silicate content in the seawater based on the Ba/Ca profile of the gastropod shells.

3.2.5. I estimated the bottom water temperature and the salinity of the Sarmatian seawater using the oxygen isotope compositions of rodent teeth and gastropod shells.

3.3. I reconstructed relative sea-level changes in the Central Paratethys during the Sarmatian based on the palaeoecological investigations of the microfauna and geochemical results. I recognized that the major palaeoenvironmental changes coincide well with the boundaries of the foraminiferal zones established by GÖRÖG (1992).

3.4. The observed high similarity suggested by the changes of the microfauna from Hungary and the similar sea-level changes in the different regions of the Paratethys indicate that the Sarmatian successions of the Zsámbék Basin well represent the major palaeoenvironmental changes in the entire Central Paratethys.

Conclusions

During the Early Sarmatian (*Elphidium reginum* Zone) the microfauna and the geochemical results suggest shallow, stable warm-temperate bottom water temperatures (~ 15°C), well ventilated, mainly brackish seawater (littoral zone, maximum 80 m deep) with rich alga and/or seagrass vegetation on the bottom and periodic phytoplankton blooms in the central basin of the Central Paratethys. In this zone a transgressive event can be observed as part of a 3rd order transgressive systems tract (TST) corresponding roughly to the TB 2.6 global cycle based on microfaunal changes and stable isotope curves. The faunal changes occurring at the boundary between the lower and the middle zone (*Elphidium reginum/Elphidium hauerinum* Zones) can be explained by a sea-level highstand with dysoxic conditions. A relative sea-level fall with a maximum depth of about 50 m, and well ventilated, warm-temperate and more brackish (17-23‰) conditions is documented at the end of this middle zone. Similar sea-level changes were demonstrated in the peripheral basins of the Central Paratethys. After a short regressive event, a marine connection was established between the Paratethys and the Mediterranean at the beginning of the upper zone (*Spirolina austriaca* Zone) based on the changes in the microfaunal composition. For the upper zone the

microfauna indicates warm (15-21°C), well-ventilated, close to normal marine shallow lagoon and marsh environments with high fluctuations in salinity (15-43 ‰). The uppermost Sarmatian more brackish ostracod assemblages indicate that a final isolation of the Central Paratethys occurred at the end of the Sarmatian. Summarizing, in contrast to the traditional interpretation of a progressive salinity decrease during the Sarmatian the isolation of the Paratethys was periodically interrupted by seawater incursions caused by renewals of the marine connections.

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Submitted papers

TÓTH, E., GÖRÖG, Á., LECUYER, C., MOISSETTE, P., BALTER, V. & MONOSTORI, M., elküldve: Palaeoenvironmental reconstruction of the Sarmatian Central Paratethys based on palaeontological and geochemical analyses of foraminifera, ostracods, gastropods and rodents. Geological Magazine